tactic (tak'tik)*n.* 1. A device or expedient for achieving a goal.

American Heritage Dictionary. New York, NY: Dell Publishing Co., Inc.

CASI White Paper

Tactical Audio for Surgical Navigation

SOUND : *i.e.*, auditory and musical perception is not used *at all* in modern surgery. CASI's new technology expands the surgeon's situational awareness using novel sonification strategies in support of tactical placement tasks. Consider the difficulty surgeons face in manually performing surgery while at the same time visually perceiving navigational guidance from a surgical planning system(e.g. digitized information is not intuitively registered and integrated with the patient). CASI addresses the problems of ergonomics delivery of the navigational guidance to the ears and hands of the operator. We base our algorithms on inverting the musical performer?s paradigm. A musician places their fingers precisely and accurately with the intent to produce sounds in ?tune?. We use elements of computer music and musical perception to enable the surgeon to place their instruments precisely and accurately by adjusting sound properties so that proper instrument placement sounds in ?tune?.

The use of audio feedback as a partial or total replacement for certain visual navigational guidance systems in the operating room can overcome this limitation. The aural modality is a comparatively rich modality which is relatively unencumbered in the operating room. Furthermore, auditory perception is both parallel - capable of discriminating between multiple simultaneous sensoria - and omnidirectional (e.g. in hearing a sound, one is not obliged to aim one? s ear directly at the sound source). We believe a properly designed and applied audio guidance system can transcend the limitation image-guided systems encounter [4], and can provide an intuitive and information-rich interface for the surgeon.

We are prototyping a commercial system for positional guidance in real-time surgical instrument placement tasks. This system will operate by translating spatial parameters of a surgical instrument or device (e.g. position or velocity) with respect to some coordinate system, into a set of audio feedback parameters along the coordinates of a generalized audio space. Placement errors corresponding to deviations of the surgical instrument trajectory from a pre-planned or optimal trajectory in computer memory will be transformed by our proposed system into a set of audio signals that will indicate to the surgeon whether correction is necessary.

Surgical Application

This system will have wide application in computer-assisted minimally invasive surgical procedures such as tumor stereotaxis. Certain image-guided surgical systems presently on the market will stand to benefit by the addition of our

technology. In fact we are currently pursuing an industrial relationship with a major vendor of such systems. In past research we assembled and tested an experimental audio feedback system using commercially available hardware and custom software algorithms [1][3]. See Fig 1. for a hardware block diagram of this system. Informal usability testing [2] in the course of the engineering process indicate that multi-channel spatialized audio position feedback can be of assistance in basic spatial placement tasks. Much research remains to be done, but the potential for this new technology is evident.

We are currently interested in developing a prototype tactical audio system as an extension to the Sofamor Danek Group?s StealthStation [5] system for image-guided stereotactical neurosurgery. In the near future we plan on pursuing this project in conjunction with the Saint Louis University (SLU) Medical School, Neurosurgical Division [6], and R. Bucholtz, M.D. Through usability testing with surgical residents at SLU, and at a later date, the performance of audio-guided neurosurgical test surgeries, we plan to develop an optimally-intuitive tactical audio system design methodology, as well as a novel and powerful surgical tool.

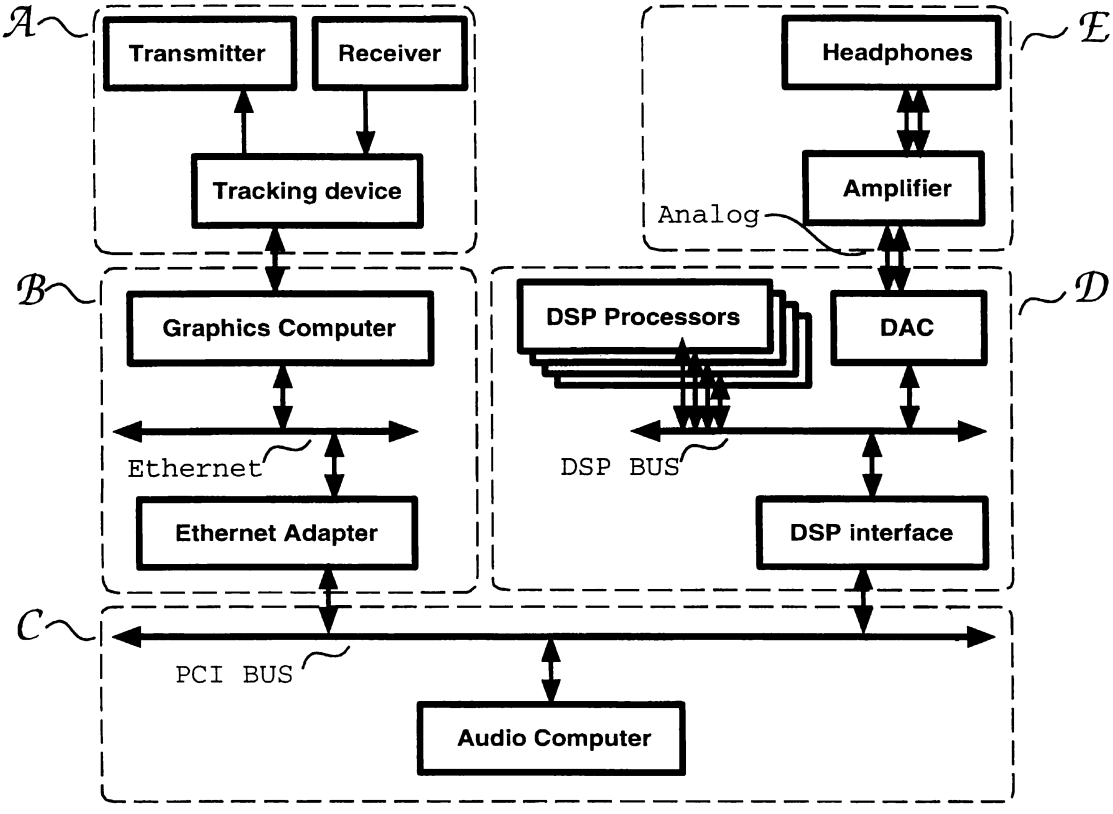

Figure 1. Audio feedback hardware system consisting of: (A) sensor subsystem, (B) graphics computer (master), (C) audio computer (slave), (D) sound synthesis and filtration subsystem, (E) amplification and public address subsystem.

About Computer Aided Surgery, Inc.

Computer Aided Surgery was founded in 1995 by D. B. Karron, Ph.D., for the research and development of advanced super-specialty computer-aided medical and virtual reality surgical technology. The basic technology of Tactical Audio has been developed with Phase 1, 2 and 3 SBIR grants (in 1996, 1997 and 1998, respectively) from DARPA DSO Advanced Biotechnology Program under the tutelage of Col. Richard M. Satava, MD. Additional funding has been provided by the NASA/Yale Commercial Space Center and Shepard Patterson, Inc. Total funding on this project

is now exceeding $985,000. For more information, contact Dr. D. B. Karron, Chief Technical Officer at karron@casi.net, voice telephone : +1 (212) 686-8748.

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